California Native Plant Society's List 1B, with the highest endangerment rating possible (California Native Plant Society 2001).

California's Wildlife Conservation Board and Public Works Board acquired Loch Lomond and a small adjacent buffer in 1988 to prevent its conversion to a recreational lake. The site is now known as the Loch Lomond Vernal Pool Ecological Reserve. In 1989, the California Department of Fish and Game, with financial assistance from us, fenced the perimeter of the lake to exclude off-road vehicles and other detrimental recreational use (U.S. Fish and Wildlife Service 1993, California Department of Fish and Game 1994). In 1994, the California Department of Fish and Game prepared a management plan for the reserve and obtained a baseline population estimate for *Eryngium constancei*. Periodic monitoring of the population and interpretive displays about the species are planned (California Department of Fish and Game 1994).

A local citizen with an interest in conservation bought the Cobb parcel where *Eryngium constancei* grows. She intends to protect the vernal pool and its associated species (J. Diaz-Haworth pers. comm. 2001, B. Flynn pers. comm. 2001). The California Department of Fish and Game has reviewed timber harvest plans and other land uses for areas adjacent to any of the populations and has provided recommendations on how to avoid impacts to *E. constancei* (*e.g.*, K. Aasen *in litt.* 1995, B. Hunter *in litt.* 1996, A. Buckmann *in litt.* 1998). In addition, their biologists conducted surveys for this species (U.S. Fish and Wildlife Service 1985b), and the agency is investigating ways to protect the Diamond Mountain occurrence (Hrusa and Buckmann 2000).

4. *LASTHENIA CONJUGENS* (CONTRA COSTA GOLDFIELDS)

a. Description and Taxonomy

Taxonomy.—Greene (1888) first described Contra Costa goldfields, naming this species *Lasthenia conjugens.* The type locality is Antioch, in Contra Costa County (Greene 1888). Hall (1914) later lumped Contra Costa goldfields with the common species Fremont's goldfields, which at that time was called *Baeria fremontii*. Ferris (1958) proposed the name *Baeria fremontii* var. *conjugens* to recognize the distinctiveness of Contra Costa goldfields. Finally, Ornduff (1966) restored Greene's original name and rank, returning this species to the genus *Lasthenia*. The two closest relatives of *Lasthenia conjugens* are *L. burkei* (Burke's goldfields) and *L. fremontii* (Fremont's goldfields).

Description and Identification.—The stems of *Lasthenia conjugens* (**Figure II-6**) are 10 to 30 centimeters (4 to 12 inches) tall, somewhat fleshy, and usually branched. The leaves are opposite and narrow; the lower leaves are entire, but stem leaves have one or two pairs of narrow lobes. The daisy-like flower heads are solitary. Both the disk and ray flowers are golden-yellow, and the ligules are 5 to 10 millimeters (0.20 to 0.39 inch) long. Each head has numerous disk flowers and 6 to 13 ray flowers. The club-shaped achenes are no more than 1.5 millimeters (0.06 inch) long and are shiny, olive-green, hairless, and lack a pappus (Greene 1888, Ornduff 1993*b*). *Lasthenia conjugens* has a diploid chromosome number of 12 (Ornduff 1966, Ornduff 1993*b*).

Whereas all other species of *Lasthenia* have either completely free phyllaries or phyllaries fused more than two-thirds of their length, *L. conjugens* has phyllaries fused from one-quarter to one-half their length. The free phyllaries and presence of a pappus distinguish both *L. burkei* and *L. fremontii* from *L. conjugens* (Ornduff *1969*, Ornduff 1979, Ornduff 1993*b*). *Blennosperma* species can be differentiated from *L. conjugens* by the alternate leaves, clustered (as opposed to solitary) flower heads, and paler yellow ligules of the former (Ornduff 1993*a,b*).

b. Historical and Current Distribution

Historical Distribution.—*Lasthenia conjugens* occurred historically in seven vernal pool regions: Central Coast, Lake-Napa, Livermore, Mendocino, Santa Barbara, Santa Rosa, and Solano-Colusa (**Figure II-7**) (Keeler-Wolf *et.al*. 1998). In addition, several historical occurrences in Contra Costa County are outside of the defined vernal pool regions (Keeler-Wolf *et al.* 1998, California Natural Diversity Data Base 2003). Many collection sites from the late 19th and early 20th centuries are difficult to pinpoint because locality information on specimen labels often was vague. Ornduff (1966) reported collections from 13 sites in Alameda, Contra Costa, Mendocino, Napa, Santa Barbara, Santa Clara, and Solano Counties. Although he cited three specimens each from Contra Costa (including the type) and Santa Barbara Counties, Ornduff (1966, 1979) noted that the species was most common in Solano County. One additional site in Alameda County was documented in 1959 by G. Thomas Robbins, who collected a specimen (# 3963, housed at the Jepson Herbarium) on the “shore of San Francisco Bay” south of Russell.

Figure II-6. Photograph of *Lasthenia conjugens* (Contra Costa goldfields). (© John Game 1998; reprinted with permission).

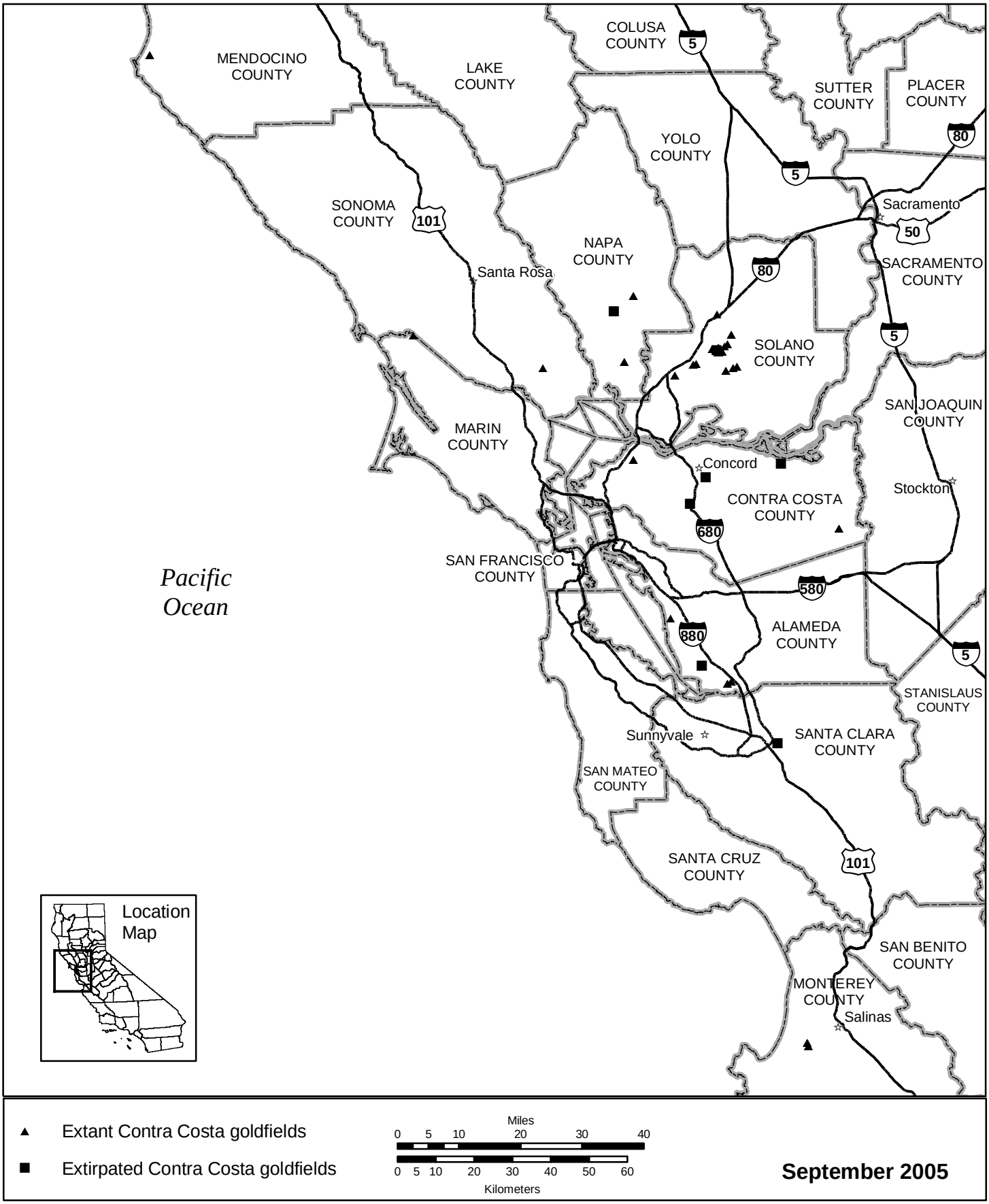

Figure II-7. Distribution of *Lasthenia conjugens* (Contra Costa goldfields).

Current Distribution.—Of the 32 occurrences of *Lasthenia conjugens* recorded between 1884 and 2003 that are currently (through August 2005) catalogued in the California Natural Diversity Data Base (2005), 22 are likely extant. Two additional populations exist at the former Fort Ord site that have not been reported to the California Natural Diversity Database (W. Collins, U.S. Army, pers. comm. 2005). Thus the total number of likely extant populations is 24. However, there is uncertainty due in part to the difficulty of relocating sites based on early vague site descriptions and also because this species may reappear on a site after several years, even if it is absent during a given survey. *Lasthenia conjugens* presumably remains in all of the vernal pool regions where it occurred historically, except for the Santa Barbara Vernal Pool Region. However, by far the greatest concentration of this species is in the Solano-Colusa Vernal Pool Region; the specific area east of Fairfield in Solano County contains 10 occurrences that are presumed extant, plus 1 that may be extirpated. Another extant occurrence is near Rodeo in Contra Costa County (California Natural Diversity Data Base 2005) which was captured within the Solano-Colusa Vernal Pool Region. Six occurrences are extant in the Central Coast Vernal Pool Region, including four at the former Fort Ord in Monterey County, one at San Francisco Bay National Wildlife Refuge, and one near Fremont, both in Alameda County (California Natural Diversity Data Base 2005). One occurrence is presumed to remain extant in the Mendocino Vernal Pool Region near Manchester in Mendocino County. In the Lake-Napa Vernal Pool Region, one occurrence is presumed to remain extant at Suscol Ridge in Napa County. Another Napa County site, Milliken Canyon, also in the Lake-Napa Vernal Pool Region contained only a single plant in 1987 and may or may not be extant (California Natural Diversity Data Base 2005). One recently discovered occurrence extends the range of *Lasthenia conjugens* to the northern part of Marin County near the boundary with Sonoma County (California Natural Diversity Data Base 2005). This location is not within the vernal pool regions covered by this plan.

c. Life History and Habitat

Little is known about this plant. However, germination, growth, reproduction, and demography are likely to be similar to *Lasthenia burkei*, a close relative that has been studied more intensively.

Reproduction and Demography.—As a vernal pool annual plant, seeds of *Lasthenia conjugens* would be expected to germinate in response to autumn rains, with the plants maturing in a single growing season, setting seed, and dying back during the summer. However, detailed research on the life cycle has not been conducted. Laboratory germination tests on the related species *L. burkei* (Rancho Santa Ana Botanical Garden unpublished data), indicated that germination occurs

rapidly in a single flush (peak germination date the same as first germination date), with relatively high germination rates (49 to 100 percent). *Lasthenia burkei* plants that establish in autumn under natural conditions may tolerate prolonged submergence but do not begin rapid stem growth until vernal pools and swales drain down during late winter or early spring (Ornduff 1969, Patterson *et al.* 1994).

Lasthenia conjugens flowers from March through June (Ornduff 1966, Ornduff 1979, Skinner and Pavlik 1994). The flowers are self-incompatible (Crawford and Ornduff 1989). Although *L. conjugens* has not been the subject of pollinator studies, observations suggest that the same insects visit all outcrossed species of *Lasthenia*, rather than concentrating on any particular species (Thorp 1976). Insect visitors to flowers of *Lasthenia* belong to five orders: Coleoptera, Diptera, Hemiptera (true bugs), Hymenoptera, and Lepidoptera (Thorp and Leong 1998). Most of these insects are generalist pollinators. All of the specialist pollinators of *Lasthenia* are solitary bees (family Andrenidae); these pollinators include two species in the subgenus *Diandrena* (*Andrena submoesta* and *A. puthua*) and five or six species in the subgenus *Hesperandrena* (*Andrena baeriae, A. duboisi, A. lativentris*, and two or three undescribed species) (Thorp and Leong 1998). The extent to which pollination of *L. conjugens* depends on host-specific bees or more generalist pollinators is currently unknown.

Seed dispersal mechanisms in *Lasthenia conjugens* are unknown. However, the lack of a pappus or even hairs on the achenes makes wind dispersal unlikely (Ornduff 1976). Seed longevity, survival rates, fecundity, and other demographic parameters have not been investigated. However, as with other vernal pool annuals, population sizes have been observed to vary by up to four orders of magnitude from year to year (California Natural Diversity Data Base 2003). Thus, this species most likely forms a persistent soil seed bank. Seeds of the related species *L. burkei* have been stored artificially for many years with little loss of viability (C. Patterson, pers. comm.). However, the maximum duration of viable seed in the soil is not known.

Habitat and Community Associations.—*Lasthenia conjugens* typically grows in vernal pools, swales, moist flats, and depressions within a grassland matrix (California Natural Diversity Data Base 2003). However, several historical collections were from populations growing in the saline-alkaline transition zone between vernal pools and tidal marshes on the eastern margin of the San Francisco Bay (P. Baye *in litt.* 2000*a*). The herbarium sheet for one of the San Francisco Bay specimens notes that the species also grew in evaporating ponds used to concentrate salt (P. Baye *in litt.* 2000*b*). The vernal pool types from which this species has been reported are Northern Basalt Flow, Northern Claypan, and Northern Volcanic Ashflow (Sawyer and Keeler-Wolf 1995). The

landforms and geologic formations for sites where *L. conjugens* occurs have not yet been determined. Most occurrences of *L. conjugens* are at elevations of 2 to 61 meters (6 to 200 feet), but the recently discovered Monterey County occurrences are at 122 meters (400 feet) and one Napa County occurrence is at 445 meters (1,460 feet) elevation (California Natural Diversity Data Base 2003).

The soil types have not yet been identified for most *Lasthenia conjugens* localities. However, soil series from which it is known are: Aiken, Antioch, Concepcion, Conejo, Crispin, Haire, Linne, Los Robles, Rincon, Solano, and San Ysidro, plus the Arnold-Santa Ynez, Hambright-rock outcrop, and Los Osos complexes. Soil textures, where known, are clays or loams. At least in Solano County and on the shores of San Francisco Bay, *L. conjugens* grows in alkaline or saline-alkaline sites (P. Baye *in litt.* 2000*a*, P. Baye *in litt.* 2000*b*, California Natural Diversity Data Base 2003).

Many plant species grow in association with *Lasthenia conjugens* in various parts of its range, but no comprehensive survey of associates has been undertaken. The two most commonly reported associates are *Lolium multiflorum* (Italian ryegrass) and *Plagiobothrys* spp. (popcorn flower). Other plant species that occur at several *Lasthenia conjugens* sites include *Cotula coronipifolia* (brass buttons), *Downingia pulchella* (valley downingia), *Eryngium aristulatum* (California eryngo), *Lasthenia glaberrima* (smooth goldfields), *Myosurus minimus* (common mousetail), and *Pleuropogon californicus* (California semaphore grass). Among the rare plants addressed in this recovery plan, those that co-occur with *Lasthenia conjugens* include *Astragalus tener* var. *tener* at two sites and *Navarretia leucocephala* ssp. *pauciflora* and *Legenere limosa* at one site each (California Natural Diversity Data Base 2003).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Lasthenia conjugens* are described below.

With the exception of Travis Air Force Base, the entire concentration area in Solano County is within the City of Fairfield's sphere of influence and subject to relatively intense development pressure under the City's general plan. Numerous construction projects, including residential development, landfill expansion, and drainage channels, are proposed and pose specific threats (U.S. Fish and Wildlife Service 1997*b*). Some projects, such as proposed highways, may disturb habitat on Travis Air Force Base as well as in the Fairfield area (U.S. Fish and Wildlife

Service 2002). Threats due to conversions to vineyards are also continuing. The largest Napa County occurrence of this plant, at Suscol Ridge (California Natural Diversity Data Base 2003), is imminently threatened by vineyard conversion; the site is already under a 25-year lease to a winery (P. Baye *in litt.* 2000*a*).

Competition from nonnative plants, particularly *Lolium multiflorum* (Italian ryegrass), threatens at least eight occurrences of *Lasthenia conjugens*, several of which are also targeted for development (California Natural Diversity Data Base 2003). Nonnative grasses such as *Lolium multiflorum* not only shade out short-statured plants like *Lasthenia conjugens*, but can also negatively impact vernal pool hydrology by decreasing inundation periods in pools (Marty 2004). In addition, encroachment by nonnative plants often follows surface-disturbing activities, such as discing, grading, filling, ditch construction, and off-road vehicle use, which can alter hydrology and microhabitat conditions. Such surface disturbances are visually apparent at nine sites occupied by *L. conjugens*, four of which do not yet have reported problems with nonnative species (California Natural Diversity Data Base 2003). Management strategies including grazing, mowing, and burning are vital to controlling these weed species. The California Natural Diversity Data Base (2003) also cites inappropriate livestock grazing practices as a threat to seven occurrences of *Lasthenia conjugens*. However, the removal of livestock grazing from at least one site in Contra Costa County has caused significant population declines in this species (J. Marty, pers. comm. 2004). Therefore, the complete elimination of grazing, as well as overgrazing, may have adverse impacts to the *Lasthenia conjugens* and other species in this plan.

e. Conservation Efforts

We listed *Lasthenia conjugens* as endangered on June 18, 1997 (U.S. Fish and Wildlife Service 1997*b*). This species does not currently have any State listing status. The California Native Plant Society has considered *L. conjugens* rare and endangered since the organization's first list was published (Powell 1974); *L. conjugens* currently is on List 1B, the highest endangerment rating possible (Skinner and Pavlik 1994). In 2005, critical habitat was designated for *L. conjugens* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Six occurrences of *Lasthenia conjugens* are on public lands: four at Fort Ord, and one each at San Francisco Bay National Wildlife Refuge and Travis Air Force Base. These lands are administered by the U.S. Bureau of Land Management, the

U.S. Fish and Wildlife Service, and the U.S. Air Force, respectively. All of the Fort Ord occurrences are on land within the Habitat Management Plan Habitat Reserve lands and will be conserved and managed in perpetuity (W. Collins *in litt*. 2005; U.S. Army Corps of Engineers 1997). The population at Travis Air Force Base, including over 20 acres of adjacent restored vernal pools, is protected as a special ecological preserve, with protective measures and appropriate management for the species provided in the Travis Air Force Base Land Management Plan.

Seasonal managed cattle grazing has been returned to two conservation sites supporting *Lasthenia conjugens*: 1) the Warm Springs Seasonal Wetland Unit of the Don Edwards San Francisco Bay National Wildlife Refuge in Alameda County, and 2) the State Route 4 Preserve managed by the Muir Heritage Land Trust in Contra Costa County. The *L. conjugens* population at the Warm Springs Unit has declined during the last 10 years due to many factors including competition by nonnative plant species. During this time period, grazing, which occurred intermittently at the Warm Springs Unit since the 1800s, has been excluded by the Refuge until a management plan could be developed. The decline in the *L. conjugens* population at the Warm Springs Unit cannot be attributed to a single factor, but most likely results from the complex interaction of several variables including current and historical land uses, the abiotic environment, and annual climatic variation. The increasing dominance of nonnative grasses, however, coincides with the suspension of livestock grazing, suggesting that the lack of a disturbance regime may be a primary factor in the degradation of habitat for *L. conjugens* at this site (U.S. Fish and Wildlife Service 2004). The population of *L. conjugens* at the State Route 4 Preserve, which was protected as part of compensation for the construction of the State Route 4 Gap Closure Project, has also declined in recent years. The decline may be due to a number of causes, including below normal precipitation and competition from nonnative species (Pardieck 2003). The site had been grazed heavily for many years resulting in stream channel erosion. Grazing was suspended in 2000 and the numbers of plants dropped sharply in 2001 and continued to decline the following year. Controlled grazing has been reintroduced to control the amount of seed and thatch produced by nonnative plants.

5. *LIMNANTHES FLOCCOSA* SSP. *CALIFORNICA* (BUTTE COUNTY MEADOWFOAM)

a. Description and Taxonomy

Taxonomy.—Before 1973, Butte County meadowfoam was not differentiated from the more widespread woolly meadowfoam (*Limnanthes floccosa* ssp. *floccosa*). Then, Arroyo (1973) determined that Butte County meadowfoam was a distinct taxon and gave it the scientific name *Limnanthes*